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Contribution of climate and land cover changes to reduction in soil erosion rates within small cultivated catchments in the eastern part of the Russian Plain during the last 60 years

Artem V. Gusarov[a], Valentin N. Golosov[b,*], Aidar G. Sharifullin[a]

[a] Institute of Environmental Sciences, Kazan Federal University, 18 Kremlyovskaya Street, Kazan 420008, Russia
[b] Faculty of Geography, Lomonosov Moscow State University, Leninskiye Gory, 1, Moscow 119991, Russia

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ABSTRACT

The eastern part of the Russian Plain is an important agricultural region of European Russia with high proportion of cultivated lands in the steppe, forest-steppe and forest (southern part) landscape zones. Soil erosion is the main process of land degradation and surface water contamination there. Climate and land cover changes have been observed in this region during the last 30 years. However, field quantitative assessments of soil erosion rates are not available for the eastern part of European Russia due to the lack of monitoring data as well as the evaluation of erosion/deposition processes in cultivated catchments using other field methods. Three representative small cultivated catchments with high (> 80%) proportion of cultivated lands were selected in the forest (southern part), forest-steppe and steppe zones of the study region to evaluate sedimentation rates in dry valley bottoms of the catchments for two-time intervals (1963–1986 and 1987–2016) based on the application of the bomb-derived and Chernobyl-derived ^{137}Cs isotope for sediment dating. The 3–4 depth ^{137}Cs profiles were used to assess the sedimentation rates within the each investigated catchment. It was established that the sedimentation rates have considerably decreased (at least 2–3 times) over the last 30 years compared to 1963–1986 in all the investigated catchments. This is in agreement with results of erosion rate calculations using erosion models for the forest zone, however not consistent with erosion rates assessments for the forest-steppe and steppe zones. According to the model calculations, erosion rates show a slight decrease in the forest-steppe zone and increase in the steppe zone. The reduction in surface runoff during snowmelt period is one of the reasons for decrease in erosion rates within cultivated slopes for all the investigated catchments. The increase in proportion of perennial grasses in the regional crop rotation is another important reason for the decrease in erosion rates for the catchment located in the south of the forest zone. The importance of land cover changes in a major decrease of soil losses from the cultivated fields of the investigated catchments located in the forest-steppe and steppe zones cannot be identified due to the lack detailed information about crop rotation for those particular sites. However, available regional information about crop rotation changes for the two-time intervals (1960–1980 and 1996–2012) do not explain very high reduction in sedimentation rates in the dry valley bottoms after 1986.

1. Introduction

It is well-known that soil degradation is one of the main threats to sustainable development of agriculture. Soil erosion is one of the main process responsible for land degradation, leading to high financial losses due to reduction of soil productivity (Pimentel, 1993; Uri and Lewis, 1998; Podmanicky et al., 2011), for lateral migration of mineral fertilizers, pesticides, heavy metals and other substances transported with sediments, eventually leading to contamination of soils located in different sediment sinks along pathways from cultivated slopes to river channels (Mullan and Favis-Mortlock, 2011), surface water pollution (Collins et al., 2012), siltation of ponds and reservoirs (Boardman et al., 2009) and eutrophication of terrestrial waterbodies (Morgan, 2009) and so on. Attempts to estimate the intensity of erosion rates under the global (and regional) climate change (Favis-Mortlock and Mullan, 2011; Mullan, 2013; Routschek et al., 2014) and land use changes (Govers et al., 2006; Cebecauer and Hofierka, 2008; Latocha et al., 2016; Golosov et al., 2017a; Vanwalleghem et al., 2017) were made for the different parts of Europe using a combination of erosion models and GIS analysis. The application of various tracers (fallout radionuclides,

* Corresponding author.
E-mail address: gollossov@rambler.ru (V.N. Golosov).

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